Journal of Tribology

Discussion

Steady-State Analysis of Mechanical Seals With Two Flexibly Mounted Rotors[1]

S. Leefe.[2] Dynamics has historically been somewhat underrepresented as a research topic in mechanical seals. Any contribution to our analytical toolbox or our state of understanding is therefore most welcome.

It is worth examining the applicability of the analysis, as presented, to cases of practical interest. In particular, the major explicit assumptions are:

- the sealed fluid is incompressible;
- there is no cavitation in the fluid film.

However, there are some significant additional assumptions carried over from the authors' previous work, in the cited references. These are:

- dynamic variation in film thickness distribution is small compared with its characteristic value (implied by the employment of linearized stiffness and damping coefficients);
- the seal is operating in the full-film noncontacting mode;
- the seal is plain-faced with coning but no waviness.

Plain-faced seals usually operate in the mixed friction regime, where film thickness is small and linearized fluid film stiffness and damping coefficients cannot be applied. Here, also, despite our best efforts, in-service waviness is ubiquitous and every bit as significant as coning in determining mean film thickness and leakage. This also gives rise, in most cases, to cavitation, unless the ambient hydrostatic pressure is high. In the discusser's opinion, in all but a limited number of cases, there is little alternative but to mount a full-frontal numerical assault on the problem of plain-faced seal dynamics, if the aim is to assess the impact of misalignment on seal performance.

The analytical framework laid out in this paper, after appropriate modification of detail, would in the discusser's opinion be of most practical benefit in the estimation of gas seal performance—where the typically high sliding speeds and low viscosity of the sealed medium often dictate seals specially designed for stable clearance operation (and the gaseous sealed fluid avoids the additional complication of cavitation). Unfortunately, this too is not without its problems since clearance operation is usually provided by means of hydrodynamic features such as grooves and Raleigh steps. This, and the presence of a gaseous sealed fluid as a mean that any stiffness and damping coefficients must be derived from a fluid film analysis based on the compressible Reynolds equation and cannot be taken from the formulas offered in this paper. However, in principle, having obtained these coefficients by whatever technique, one could justifiably apply the current approach to estimate dynamic response. It is the discusser's opinion that an estimate of performance might prove more reliable in these circumstances.

In conclusion, the real value of the work presented here in this most difficult of areas is that the authors have laid down the analytical framework for the most general dynamic analysis where both seal rings rotate and are flexibly mounted. For this they are to be congratulated.

Authors' Closure

The authors would like to thank Dr. Leefe for his interest in the paper and for his thoughtful input. Dr. Leefe correctly states most of our assumptions, then makes two different points. The first is specific, regarding the applicability of the authors' assumptions to cases of practical interest, while the second is philosophical, regarding the relative merits of theoretical versus numerical analysis. We shall consider these two issues separately, then attempt to tie them together.

We agree that the most restrictive of our assumptions is the requirement of a full fluid film, which does not always exist in seals. However, in seals with operating speeds high enough to cause failure resulting from dynamic effects, contact would generally be a serious problem. Our model can predict the point at which contact occurs, and we assume that this contact constitutes seal failure.

The authors have also encountered the problem of waviness in their own experimental work and agree that it exists in most real seals. However, the computation of this waviness itself requires a number of assumptions regarding structural and heat transfer boundary conditions and heat generation within the film and support, so that its inclusion in the analysis often adds an additional series of questionable assumptions.

Finally, the authors maintain their assertion that small motions are the only motions possible in a seal for which failure has been defined as face contact, and that these motions must necessarily occur about an equilibrium position in steady-state operation.

Dr. Leefe then proposes that the only valid approach is often a ''full-frontal numerical assault.'' While the authors agree that numerical tools have an important place in seal analysis, we believe that a false dichotomy exists between theoretical and numerical analysis in the minds of many engineers, and that numerical analysis is not a panacea for resolving the unknowns in a seal analysis.

First, numerical analysis often presents similar problems with assumptions. For example, face contact, waviness, cavitation, and compressibility can be modeled numerically, but fall victim, as described above, to problems of choosing a contact model and assuming boundary conditions. Analysis, either numerical or theoretical, can only serve to provide a first approximation

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[1] By J. Wileman and I. Green published in the January 1997 issue of the JOURNAL OF TRIBOLOGY, Vol. 119, pp. 200–204.

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